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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H02K 15/02

A1

(11) International Publication Number: WO 99/19970

(43) International Publication Date: 22 April 1999 (22.04.99)

(21) International Application Number: PCT/SE98/01834

(22) International Filing Date: 12 October 1998 (12.10.98)

(30) Priority Data:
9703720–4 13 October 1997 (13.10.97) SE

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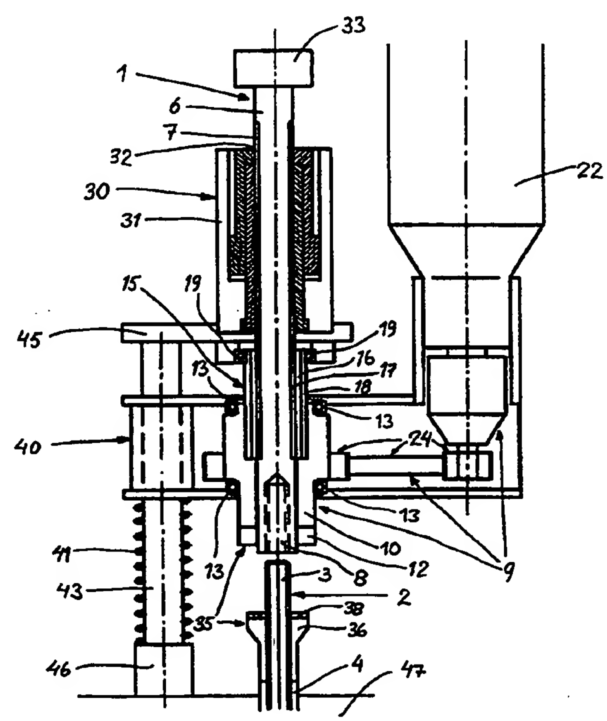
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, ES, FI, FI (Utility model), GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: A STATOR AND A METHOD FOR MANUFACTURING A STATOR

(57) Abstract

The present invention relates to a method for manufacturing a stator for a rotating electric machine for high voltage, which stator is provided with a winding arranged in slots in the stator core and which stator is built up of segments held together by tightening means (2), which are prestressed by means of a tension means (1). The invention also relates to a device for performing the method, a stator manufactured in accordance with the method, and a rotating electric machine including such a stator.



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A STATOR, AND A METHOD FOR MANUFACTURING A STATOR

The present invention relates to a method for manufacturing a stator for a rotating electric machine for high voltage in accordance with the preamble to claim 1, a stator manufactured in accordance with the method defined in claim 2 and a device for prestressing and securing tightening means in accordance with the preamble to claim 11.

The invention also relates to a use of said device in accordance with claim 26, yet a method for manufacturing a stator in accordance with the preamble to claim 27 and a stator in accordance with the preamble to claim 28.

The invention is particularly suitable for use with rotating electric machines for high voltages including a stator, a rotor and at least one winding, in which bolts of preferably glass fibre are used to hold together segments, preferably of electrical sheet, forming the stator of the machine.

The present invention therefore also relates to a rotating electric machine in accordance with the preamble to claim 29.

The rotating electric machines referred to in this context include synchronous machines, principally used as generators for connection to distribution and transmission networks, generally termed power networks. The synchronous machines are also used as motors and for phase compensation and voltage control, in that case as open-circuited machines. This technical area also includes normal asynchronous machines, double-fed machines, alternating current machines, asynchronous static current converter cascades, external pole machines and synchronous flux machines. These machines are intended for use at high voltages, by which is meant here electric voltages in excess of 10 kV. A typical operating range for such a rotating machine may be 36 to 800 kV, preferably 72.5 - 800 kV.

Rotating electric machines have conventionally been designed for voltages in the range 6-30 kV, and 30 kV has

normally been considered to be an upper limit. This generally means that a generator must be connected to the power network via a transformer which steps up the voltage to the level of the network, i.e. in the range of approximately 130-400 kV.

Various attempts have been made over the years to develop especially synchronous machines, preferably generators, for higher voltages. Examples of this are described, for instance, in "Electrical World", October 15 1932, pages 524-525, the article entitled "Water-and-Oil-cooled Turbogenerator TVM-300" in J. Elektrotechnika, No. 1, 1970, pages 6-8 and the patent publications US 4,429,244 and SU 955,369. However, none of these attempts has been successful, nor have they led to any commercially available product.

It has, however, proved possible to use high-voltage insulated electric conductors with solid insulation of a similar type to cables for transmitting electric power (e.g. XLPE cables), as stator winding in a rotating electric machine. This allows the voltage of the machine to be increased to such levels that it can be connected directly to the power network without intermediate transformers. The extremely important advantage is thus gained, inter alia, that the conventional transformer can be eliminated.

The insulated conductor or high-voltage cable used in the present invention is flexible and of a kind which is described in more detail in WO 97/45919 and WO 97/45847. Additional descriptions of the insulated conductor or cable concerned can be found in WO 97/45918, WO 97/45930 and WO 97/45931.

In conventional types of rotating electric machines the stator frame often consists of a welded steel plate construction. In large machines the stator core, also known as the laminated core, is normally made of so called electrical sheet, preferably 0.35-0.50 mm, divided into stacks having an axial length of approximately 50 mm, separated from each other by spacers forming ventilation ducts 5 to

15 mm wide. In large machines each laminated stack is formed by adding sheet segments, punched to a suitable size, together to form a first layer. The sheet segments in each subsequent layer are placed with overlap on the segments in the preceding layer. The laminated part of a stator core has been formed when all the layers, possibly with ventilation ducts between them, have been placed. The parts and spacers are held together with existing axial clamping means in the form of pressure brackets pressed by means of pressure devices against pressure rings, fingers or segments.

A new type of arrangement for axial compression of the laminated stack or segment of the laminated stack has, however, proved possible for use in the above-mentioned new type of rotating electric machine. The device is a tightening means including axially running bolts which have preferably been electrically insulated or are provided with an insulating material, which are drawn through axial holes through the stator teeth and possibly through the stator yoke. The bolts run in the stator teeth or in the stator yoke along the entire axial length of the stator, and are provided with locking devices. The locking device may consist of a nut at one end and the head of the bolt at the other end. Alternatively the tightening means is made in the form of a rod at least partially threaded internally and/or externally, in which case the locking devices may consist of nuts at both ends, for instance. It is also possible for the rod to be hollow, in which case it may also be used as a combined cooling duct.

One way of achieving said tightening means is to design them as glass fibre rods, secured by means of glass fibre nuts. However, the friction of this material is high and conventional prestressing using dynamometric tools is therefore impossible.

The object of the present invention is to solve the problems mentioned above. This object is achieved by means of the method according to the preamble of claim 1 with the features defined in the characterizing part of the claim.

The object is also achieved with a stator in accordance with claim 2 which is characterized in that it is manufactured in accordance with the method defined in claim 1.

The method is thus characterized in that

• a tightening means, in the form of an at least partially threaded rod, is placed in a recess, preferably through-running, intended therefor in the stator core and in that a nut pertaining to the tightening means is screwed loosely onto the threaded end of the rod, which end protrudes out of the stator core,

• a tension means is screwed onto the threaded end of the rod protruding from the stator core,

• the tightening means is prestressed by the tension means acting upon the threaded rod with a predetermined tensile force with the aid of a prestressing means,

• the nut is tightened to retain and secure the prestressing, and

• the winding is achieved with an electric conductor including at least one current-carrying conductor, and also including a first layer with semiconducting properties surrounding the current-carrying conductor, a solid insulating layer surrounding said first layer, and a second layer with semiconducting properties surrounding the insulating layer.

The method described has the advantage that it solves the problem of prestressing the glass fibre bolts, thus enabling their use in the present context.

As mentioned above, the windings, in the method and stator according to the invention, are preferably of a type corresponding to cables having solid, extruded insulation, of a type now used for power distribution, such as XLPE-cables or cables with EPR-insulation. Such a cable comprises an inner conductor composed of one or more strand parts, an inner semiconducting layer surrounding the conductor, a solid insulating layer surrounding this and an outer semiconducting layer surrounding the insulating layer. Such cables are flexible, which is an important property in this

context since the technology for the method and stator according to the invention is based primarily on winding systems in which the winding is formed from cable which is bent during assembly. The flexibility of an XLPE-cable normally corresponds to a radius of curvature of approximately 20 cm for a cable with a diameter of 30 mm, and a radius of curvature of approximately 65 cm for a cable with a diameter of 80 mm. In the present application the term "flexible" is used to indicate that the winding is flexible down to a radius of curvature in the order of four times the cable diameter, preferably eight to twelve times the cable diameter.

The winding should be constructed to retain its properties even when it is bent and when it is subjected to thermal or mechanical stress during operation. It is vital that the layers retain their adhesion to each other in this context. The material properties of the layers are decisive here, particularly their elasticity and relative coefficients of thermal expansion. In an XLPE-cable, for instance, the insulating layer consists of cross-linked, low-density polyethylene, and the semiconducting layers consist of polyethylene with soot and metal particles mixed in. Changes in volume as a result of temperature fluctuations are completely absorbed as changes in radius in the cable and, thanks to the comparatively slight difference between the coefficients of thermal expansion in the layers in relation to the elasticity of these materials, the radial expansion can take place without the adhesion between the layers being lost.

The material combinations stated above should be considered only as examples. Other combinations fulfilling the conditions specified and also the condition of being semiconducting, i.e. having resistivity within the range of 10^{-1}-10^{6} ohm-cm, e.g. 1-500 ohm-cm, or 10-200 ohm-cm, naturally also fall within the scope of the invention.

The insulating layer may consist, for example, of a solid thermoplastic material such as low-density polyethyl-

ene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polybutylene (PB), polymethyl pentene ("TPX"), cross-linked materials such as cross-linked polyethylene (XLPE), or rubber such as ethylene propylene rubber (EPR) or silicon rubber.

The first, inner, and the second, outer, semiconducting layers may be of the same basic material but with particles of conducting material such as soot or metal powder mixed in.

The mechanical properties of these materials, particularly their coefficients of thermal expansion, are affected relatively little by whether soot or metal powder is mixed in or not - at least in the proportions required to achieve the conductivity necessary according to the invention. The insulating layer and the semiconducting layers thus have substantially the same coefficients of thermal expansion.

Ethylene-vinyl-acetate copolymers/nitrile rubber (EVA/NBR), butyl graft polyethylene, ethylene-butyl-acrylate copolymers (EBA) and ethylene-ethyl-acrylate copolymers (EEA) may also constitute suitable polymers for the semiconducting layers.

Even when different types of material are used as base in the various layers, it is desirable for their coefficients of thermal expansion to be substantially the same. This is the case with the combination of the materials listed above.

The materials listed above have relatively good elasticity, with an E-modulus of E<500 MPa, preferably <200 MPa. The elasticity is sufficient for any minor differences between the coefficients of thermal expansion for the materials in the layers to be absorbed in the radial direction of the elasticity so that no cracks appear, or any other damage, and so that the layers are not released from each other. The material in the layers is elastic, and the adhesion between the layers is at least of the same magnitude as in the weakest of the materials.

The conductivity of the two semiconducting layers is sufficient to substantially equalize the potential along each layer. The conductivity of the outer semiconducting layer is sufficiently high to enclose the electrical field within the cable, but sufficiently low not to give rise to significant losses due to currents induced in the longitudinal direction of the layer.

Thus, each of the two semiconducting layers essentially constitutes one equipotential surface, and these layers will substantially enclose the electrical field between them.

There is, of course, nothing to prevent one or more additional semiconducting layers being arranged in the insulating layer.

The method is, however, if performed manually, extremely time-consuming since the number of bolts is often considerable. Another object of the present invention is therefore to reduce the time required for prestressing and securing said bolts in the stator of a rotating electric machine. This object is achieved with a device for prestressing and securing tightening means as described in the preamble of claim 11, with the addition of the advantageous features defined in the characterizing part of the claim.

Thus, by providing a device including a tension means with a tension rod which is screwed onto a tightening means in the form of a rod, provided at least partially with threading and with a nut screwed on, and also including rotating means to impart a rotary movement to the tension rod in order to screw on or unscrew the tension rod from the tightening means and subsequently transfer a rotary movement to the nut, means for connecting said rotating means with the tension means, means for prestressing the tightening means by affecting the tension rod to a pre-set position, and means for tightening the nut in the prestressed position of the tightening means, the method described above can be performed mechanically in an extremely efficient manner.

This device is thus not limited to any particular area of application but can be used in any context demanding prestressing of tightening means, preferably in the form of bolts. The term "tightening means" is used in the claims and this may refer to a bolt, for instance, but similar means such as a threaded pin are also possible as mentioned previously. Neither is the device in any way limited to the prestressing of glass fibre bolts. Any other type of bolt is possible. However, it is particularly advantageous for prestressing bolts of various types of materials that are difficult to prestress, of which glass fibre may be mentioned as an example. Other examples may be non-magnetic polymer materials or carbon fibre.

Other advantages and characteristics will be revealed in the dependent claims.

In accordance with the stator according to the invention, the high-voltage electric conductor may be manufactured in several advantageous ways. According to one advantageous feature the insulated conductor is a cable, preferably a high-voltage cable.

In accordance with a preferred embodiment the conductor or cable is flexible. It is important for the cable to flexible or bendable if it is to be used as a winding. Furthermore, the first semiconducting layer is at substantially the same potential as the current-carrying conductor. The second semiconducting layer is preferably arranged so that it constitutes a substantially equipotential surface surrounding the current-carrying conductor(s) and the insulating layer. It is also connected to a predetermined potential, preferably earth potential. In accordance with other characteristics at least two adjacent layers have substantially equally large coefficients of thermal expansion and the current-carrying conductor may include a number of strand parts, only a few of the strand parts not being insulated from each other.

Furthermore, each of the three layers, i.e. the two semiconducting layers and the insulating layer, may be

firmly joined to the adjacent layer along substantially its entire contact surface. In accordance with a particularly important characteristic the layers are arranged to adhere to each other even when the insulated conductor or cable is bent. Finally, it may be mentioned that it preferably has a diameter within the range 20-250 mm and a conducting area in the range 80-3000 mm^2.

As to the device, in accordance with an advantageous embodiment, the rotation means include a rotatable holder means and drive means for rotation of the holder means. The rotatable holder means is preferably formed as a sleeve, generally in the form of a chuck, but other forms, known per se, for the holder means are also conceivable. The drive means preferably include a drive motor, preferably electric, for instance in the form of a drilling machine, suitably hand-held, and a transmission means, where the transmission means may include a cogged belt transmission. However, other types of transmission means may also be suitable, e.g. V-belt or chain transmission.

In accordance with another advantageous embodiment the means for connecting the rotating means with the tension means constitutes a rotatable sleeve provided with splines, termed a connecting sleeve. In accordance with a preferred embodiment the sleeve is provided internally with splines for cooperation with corresponding external splines arranged on the tension rod. The sleeve is also provided externally with splines for cooperation with corresponding internal splines on the holder means. Other types of rotatable connecting means are feasible.

In accordance with another feature the means for prestressing include a hydraulic cylinder and a hydraulic pump, the hydraulic cylinder being designed to influence the tension rod with a tensile force so that the tension rod and the bolt joined thereto are tightened to a pre-set, or in some way predetermined, position. Other prestressing means are naturally also feasible, e.g. equivalent pneumatic

means, a linear motor, or any other means able to execute a linear movement.

The device is also characterized in that the means for tightening the nut include the holder means and means for detachable connection of the holder means with the nut, preferably in the form of a carrier means.

Additional advantageous features that may be mentioned are that the device includes a stand on which the rotating means are supported. This stand is in turn supported on at least one, preferably two, pillars and is able to move axially along the pillars in resilient manner. The arrangement with the stand and pillars improves the stability of the device and facilitates exactitude when fitting the tension rod over the bolt, thereby enabling the work of prestressing and securing to be performed more quickly. The pillars may also be provided with a cross piece on which the tension means, spline sleeve and prestressing means are supported. To further improve stability the pillars may be attached on one or more support rails bearing onto the generator or any other arrangement where the device is being used.

The objects of the present invention stated above can also be achieved by the use of a device in accordance with any of the claims relating to a device, when manufacturing a stator in accordance with any of the claims relating to a stator. They can also be achieved by a method characterized in that the stator is manufactured with the aid of said device or by a stator characterized in that it is manufactured by means of said device, and also by a rotating electric machine characterized in that it includes a stator as defined in any of the claims relating to a stator.

To summarize, it should be mentioned that a considerable advantage is gained with the proposed invention since the work of prestressing the bolts for holding together the electrical sheet segments in a stator core for a rotating electric machine, particularly a generator, is simplified to such an extent that the total process time for bolt tighten-

ing is reduced from weeks to hours. It is usual for a generator to have several hundred such bolts.

To increase understanding of the invention it will now be described in detail with reference to the accompanying drawings illustrating a non-limiting embodiment by way of example, in which

Figure 1 shows a device in accordance with the present invention, in a front view and partly in section along the line A-A in Figure 4, in a first position,

Figure 2 illustrates a device in accordance with the present invention, in a side view and partly in section along the line A-A in Figure 4, in a second position

Figure 3 illustrates a device in accordance with the present invention, in a front view and partly in section along the line A-A in Figure 4, in a third position

Figure 4 shows the device in accordance with the present invention schematically, seen from above and partly in section, immediately above the wheels in the transmission means,

Figure 5 shows a sector of a stator with the bolts outlined in accordance with the invention, and

Figure 6 shows a section through an insulated electric conductor suitable for use as winding.

The device illustrated in Figure 1 is an embodiment by way of example of a device in accordance with the present invention, which is particularly suitable for prestressing and securing bolts used to hold together the electrical sheet segments in the stator of a generator. The bolt 2 is here a threaded rod 3 provided with a nut 4. The bolt, preferably made of glass fibre, is loosely fitted in the stator 47 and is provided with a nut screwed on. The nut is preferably screwed on with the aid of a drilling machine with a special sleeve to fit these nuts.

The device includes a tension means 1 with a tension rod 6 provided externally with splines 7. An actuator means 33 is provided at its upper end. The tension rod is provided at its lower end, facing the bolt, with an internally

threaded recess 8. The device also includes prestressing means 30 including a hydraulic cylinder 31 provided with a hollow shaft 32 and a hydraulic pump (not shown). The hydraulic pump is preferably electrically operated at constant pressure, e.g. a wing pump. The tension rod 6 is arranged in the hollow shaft 32.

The device also includes rotating means 9 to impart a rotary movement to the tension rod. The rotating means include drive means in the form of a drive motor 22 and preferably also a transmission means 24, as well as a rotatable holder means 10 applied on the tension rod. In the example illustrated the transmission means is a cogged belt transmission means, which is described in more detail with reference to Figure 4. In the example illustrated the holder means consists of a rotatable sleeve in the form of a chuck. As illustrated, the drive motor may also consist of a drilling machine. The tension rod 6 and chuck 10 are joined together by means of a rotatable connecting means 15. In the example illustrated this connecting means 15 consists of a sleeve 16, said connecting sleeve being provided internally with splines 17 and externally with splines 18. The internal splines 17 cooperate with corresponding external splines 7 on the tension rod 6. Said external splines 18 cooperate with corresponding internal splines 11 (only illustrated in Figure 4) on the chuck 10. Other types of rotatable connecting means are of course possible.

The device also includes means 35 for tightening the nut after the prestressing operation has been performed. The chuck 10 is thus provided with slots 12 which include screw-driver slots in the embodiment shown. A carrier means 36 is arranged on the bolt 2, the carrier means having a central aperture which is fitted over the bolt, and with slots, e.g. in the form of screw-driver slots, in the end facing the nut, for cooperation with corresponding slots arranged in the nut. The carrier means is also provided with slots, preferably screw-driver slots 38, corresponding to the slots in the chuck, for cooperation therewith. Also other means

for connecting the chuck to the carrier means are feasible. It is also possible in certain cases to omit the carrier means, in which case the chuck 10 is instead provided at its lower end facing the bolt, with means for cooperating directly with the nut 4 on the bolt. The reason a carrier means is required in the case illustrated is that the nut shall be screwed down into the stator 47 and there is not sufficient space for the chuck.

The drive motor, transmission means and chuck are supported on a stand 40. This stand is axially movable, spring-supported and runs on two pillars 43, 44 with the aid of ball bushings or the like. These pillars 43, 44 are connected by a cross piece 45, on which the hydraulic cylinder 31 is mounted. The splined sleeve 16 is fitted onto the underside of the cross piece. It is fitted with ball bearings 19 so that the sleeve can rotate but is simultaneously fixed axially to the cross piece. The chuck 10 is supported on the stand by means of ball bearings 13.

The device is advantageously provided with two support rails 46 with the aid of which the device is supported against the generator. The pillars 43, 44 are arranged on these rails.

The two support rails 46 and the pillars 43, 44 are revealed in Figure 4. This figure also shows the cogged belt transmission 24 with two wheels 26, 27, and the cogged belt 25. The rotary movement is transmitted from the drive motor 22 with the aid of the cogged belt transmission, the wheel 26 being arranged on the outgoing shaft of the motor, via the cogged belt 25 to the wheel 27, the latter being arranged on and driving the chuck 10.

Figure 4 also shows the internal splines 11 on the chuck 10 cooperating with the external splines 18 of the sleeve 16, as well as the internal splines 17 cooperating with the external splines 7 of the tension rod 6.

Figure 5 shows a sector 50 of a stator in accordance with the invention. The stator sector includes six stator teeth 51, four of which are provided respectively with a

pressure finger 52 in the example illustrated. The winding 53 is arranged in the space 54 shaped like a bicycle chain. The bolts 57 are arranged in the stator teeth 51 and also in the stator yoke 58. Cooling ducts 59 are also shown in the figure.

Figure 6, finally, shows a cross section through a cable which is particularly suitable for use as winding in the stator in accordance with the present invention. The cable 60 includes at least one current-carrying conductor 61, surrounded by a first semiconducting layer 62. An insulating layer 63 is arranged surrounding this first semiconducting layer and a second semiconducting layer 64 is arranged surrounding the insulating layer. The electric conductor 61 may consist of a number of strand parts 65. The three layers are made so that they adhere to each other even when the cable is bent. The cable shown is flexible and this property is retained throughout its service life. The cable illustrated also differs from conventional high-voltage cable in that the outer mechanically protective sheath and the metal screen normally surrounding such a cable do not have to be included.

The function of the device will now be described with reference to Figure 1, Figure 2 and Figure 3 in which various stages of the working operation are illustrated.

The glass fibre bolts are presumed to be loosely mounted in the stator with the nuts screwed on. The nuts may be screwed on, for instance, using a drilling machine with a special sleeve to fit these nuts. The device in accordance with the invention is placed so that the tension means 1 with the tension rod 6 is situated exactly over a glass fibre bolt 2, as illustrated in Figure 1. In this position the tension rod is lowered with the aid of the actuator 33 arranged at the upper end of the tension rod, and the drive motor is started. Since the tension rod is provided with a recess 8 with internal threading at the end facing the bolt, this will engage with the threaded rod 3 of the bolt 2. This is illustrated in Figure 2. Alternatively the bolt may have

a recess with internal threading and the tension rod have corresponding external threading for cooperation. The rotary movement from the rotating chuck is transmitted to the tension rod by means of the splined sleeve 16 and corresponding splines in chuck and tension rod. When the tension rod has been screwed on sufficiently far onto the glass fibre bolt, which may be 25-30 mm, see Figure 2, the drive motor is stopped. Prestressing of the glass fibre bolt is now effected by the hydraulic pump pressing out the hydraulic cylinder 31, thereby influencing the tension rod 6 and the bolt 2 (the threaded rod 3) connected thereto, with a predetermined tensile force. The hydraulic pump retains its pressure until the nut has been finally tightened.

Final tightening of the nut is achieved as illustrated in Figure 3. The stand 40, with the rotating chuck 10 and drive motor 22, is pressed downwards against the action of the spring 41 until the splined sleeve 16 is free of the chuck. The drive motor is then started. The chuck now rotates without the tension rod rotating. The nut can now be firmly tightened via the screw-driver slots 12 in the chuck, the carrier means 36 with its corresponding screw-driver slots 38, and the cooperating slots in the nut and carrier means. The hydraulic pressure is then released. The chuck and the stand then move upwards, pressed by the spring 41, so that the splined sleeve is once more in engagement and the drive motor is driven in the opposite direction until the tension rod releases the glass fibre bolt. The device is now ready to be moved to the next glass fibre bolt where the procedure is repeated.

The above description of the exemplified embodiment shall not be considered limiting. A number of variations are feasible within the scope of the appended claims.

CLAIMS

1. A method for manufacturing a stator for a rotating electric machine for high voltage, which stator is provided with a winding arranged in slots in a stator core and which stator is built up of segments held together by tightening means (2), characterized in that

- said tightening means (2) in the form of an at least partially threaded rod (3) is placed in a recess intended therefor in the stator core and in that a nut (4) pertaining to the tightening means is screwed loosely onto the threaded end of the rod, which end protrudes out of the stator core,
- a tension means (1) is screwed onto the threaded end of the rod protruding from the stator core,
- the tightening means (2) is prestressed by the tension means acting upon the threaded rod with a predetermined tensile force with the aid of a prestressing means (30),
- the nut (4) is tightened to retain and secure the prestressing, and
- the winding is achieved with an electric conductor (60) including at least one current-carrying conductor (61), and also including a first layer (62) with semiconducting properties surrounding the current-carrying conductor, a solid insulating layer (63) surrounding said first layer, and a second layer (64) with semiconducting properties surrounding the insulating layer.

2. A stator for a rotating electric machine for high voltage, characterized in that it is manufactured in accordance with the method defined in claim 1.

3. A stator as claimed in claim 2, characterized in that the insulated conductor is a cable, preferably a high-voltage cable.

4. A stator as claimed in any of the preceding claims, characterized in that the insulated conductor (60) or cable is flexible.

5. A stator as claimed in any of the preceding claims, characterized in that the second layer (64) is arranged so that it constitutes a substantially equipotential surface surrounding the current-carrying conductor(s) (61).

6. A stator as claimed in any of the preceding claims, characterized in that the second layer (64) is connected to earth potential.

7. A stator as claimed in any of the preceding claims, characterized in that at least two adjacent layers have substantially equally large coefficients of thermal expansion.

8. A stator as claimed in any of the preceding claims, characterized in that each of said three layers is firmly joined to the adjacent layer along substantially its entire contact surface.

9. A stator as claimed in any of the preceding claims, characterized in that said layers are arranged to adhere to each other even when the insulated conductor (60) or cable is bent.

10. A stator as claimed in any of the preceding claims, characterized in that the tightening means (2) is made of a material having relatively high surface friction, preferably glass fibre.

11. A device for prestressing and securing tightening means (2), preferably bolts for holding together the stator core in a rotating electric machine, particularly for high

voltage, characterized in that it includes a tension means (1) with a tension rod (6) which is screwed onto a tightening means (2) in the form of a rod (3) provided at least partially with threading and with a nut (4) screwed on, and in that it also includes rotating means (9) to impart a rotary movement to the tension rod in order to screw on or unscrew the tension rod from the tightening means and subsequently transfer a rotary movement to the nut, means for connecting (15) said rotating means with the tension means, means for prestressing (30) the tightening means to a pre-set position by acting upon the tension rod, and means (35) for tightening the nut in the prestressed position of the tightening means.

12. A device as claimed in claim 11, characterized in that said rotating means (9) includes a rotating holder means (10) and drive means (22, 24) for rotation of the holder means.

13. A device as claimed in claim 12, characterized in that said drive means include a drive motor (22) and a transmission means (24) for transferring a rotary movement from the drive motor to the holder means (10).

14. A device as claimed in claim 13, characterized in that the transmission means (24) includes a cogged belt transmission.

15. A device as claimed in any of the preceding claims, characterized in that said means for connecting (15) said rotating means with the tension rod (1) is in the form of an element for detachable connection between the holder means (10) and the tension rod (1).

16. A device as claimed in claim 15, characterized in that the connecting means (15) is a rotatable connecting sleeve (16) provided internally with splines (17) and in

that the tension rod (6) is provided externally with splines (7) for cooperation with the internal splines of the connecting sleeve, in that the connecting sleeve is also provided externally with splines (18) and in that the holder means (10) is provided with corresponding internal splines (11) for cooperation with the external splines of the connecting sleeve.

17. A device as claimed in any of the preceding claims, characterized in that the holder means (10) is formed as a sleeve, preferably a chuck.

18. A device as claimed in any of the preceding claims, characterized in that said means for prestressing (30) include a hydraulic cylinder (31) with a hollow shaft (32) in which the tension rod (1) is fitted, and a hydraulic pump, said hydraulic cylinder being adapted to act upon the tension rod with a tensile force so that the tension rod (6) and the tightening means (2) joined thereto are tightened to a pre-set position.

19. A device as claimed in any of the preceding claims, characterized in that said means (35) for tightening the nut include said holder means (10) and means (36) for detachable connection of the holder means with the nut.

20. A device as claimed in claim 19, characterized in that said means (36) for connection of the holder means (10) with the nut (4) includes a carrier means (36) applied on the nut and provided with recesses (38) at its end facing away from the nut, and in that the holder means (10) is provided with corresponding recesses (12) at its end facing the carrier means, for cooperation with said recesses in the carrier means, and in that the carrier means is also provided with recesses at its end facing the nut for cooperating with corresponding recesses in the nut.

21. A device as claimed in any of the preceding claims, characterized in that the rotating means (9) are arranged on a stand (40) movable in axial direction in relation to the tension rod (1) and the prestressing means (30).

22. A device as claimed in claim 21, characterized in that it includes at least one pillar (43, 44) on which the stand (40) is supported, and in that said pillar is provided with a cross piece (45) on which prestressing means (30), tension rod (1) and said means for connection (15) of the rotating means (9) with the tension rod are supported.

23. A device as claimed in claim 22, characterized in that it includes at least two pillars (43, 44) joined by means of said cross piece (45), in that the stand (40) is resiliently supported on the pillars and designed to move axially along the pillars, in that the hydraulic cylinder (31) is mounted on the upper side of said cross piece, and in that the connecting sleeve (16) is mounted with the aid of bearings (19) on the underside of said cross piece, said connecting sleeve being rotatable but at the same time being axially in a fixed position against the cross piece.

24. A device as claimed in any of claims 22-23, characterized in that the pillars (43, 44) are attached to at least one support rail by means of which the device can abut against the device into which the tightening means are to be screwed.

25. A device as claimed in any of the preceding claims, characterized in that it also includes means for screwing a nut onto a tightening means before the tension rod is screwed onto the tightening means.

26. The use of a device as claimed in any of claims 11-25, for prestressing and securing tightening means for holding together a stator core in a rotating electric machine,

said tightening means including an at least partially threaded rod and a nut, when manufacturing a stator as claimed in any of claims 2-10.

27. A method for manufacturing a stator for a rotating electric machine for high voltage, which stator is provided with a winding arranged in slots in a stator core and which stator is built up of segments held together by tightening means (2), characterized in manufacturing the stator with the aid of a device as claimed in any of claims 11-25, for tightening and securing the tightening means for holding together the stator core, said tightening means including an at least partially threaded rod and a nut.

28. A stator for a rotating electric machine for high voltage, which stator is provided with a winding arranged in slots in a stator core and which stator is built up of segments held together by tightening means (2), characterized in that it is manufactured with the aid of a device as claimed in any of claims 11-25, for tightening and securing the tightening means for holding together the stator core, said tightening means including an at least partially threaded rod and a nut.

29. A rotating electric machine for high voltage, characterized in that it includes a stator as claimed in any of claims 2-10 or 28.

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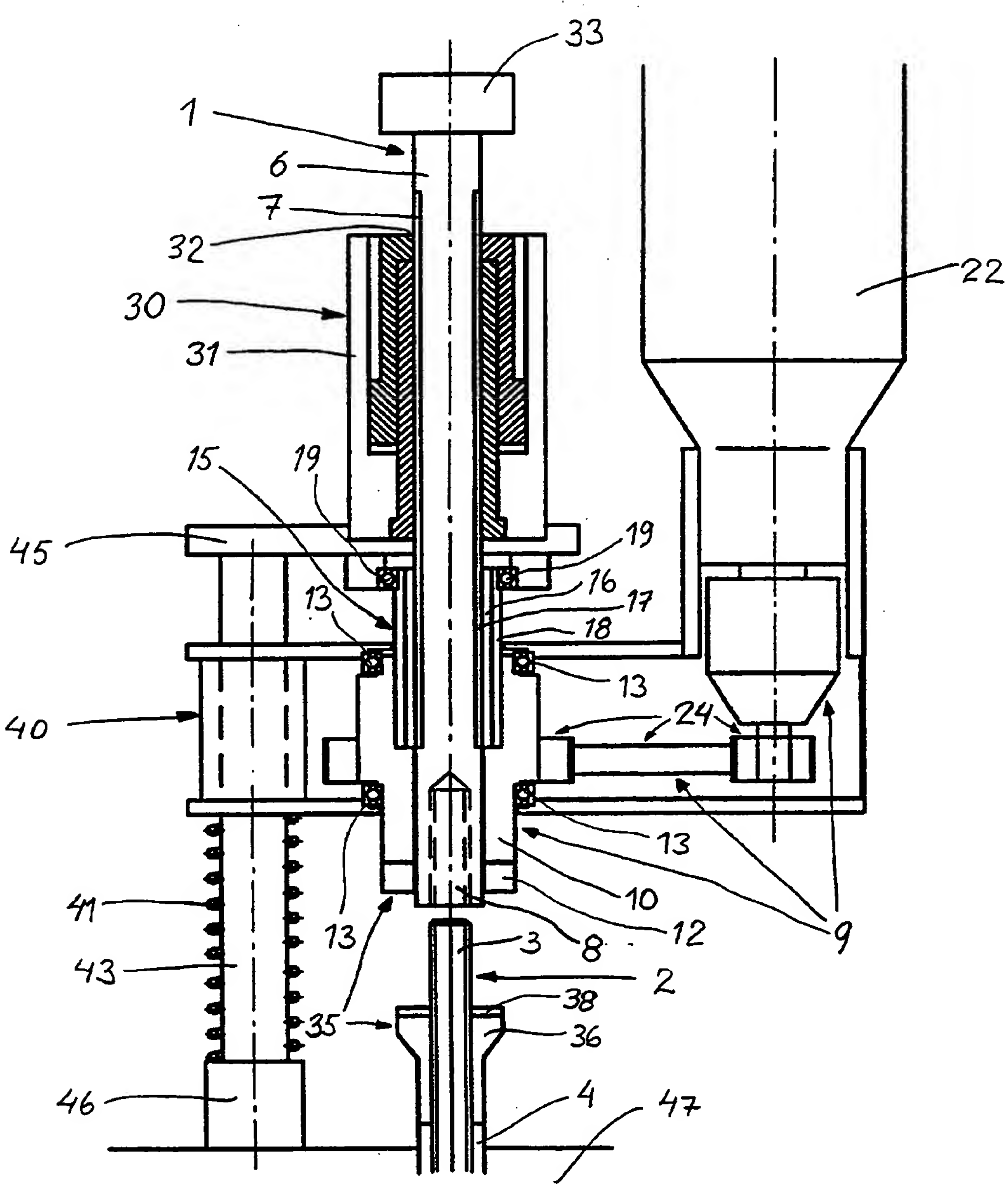
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Fig. 1

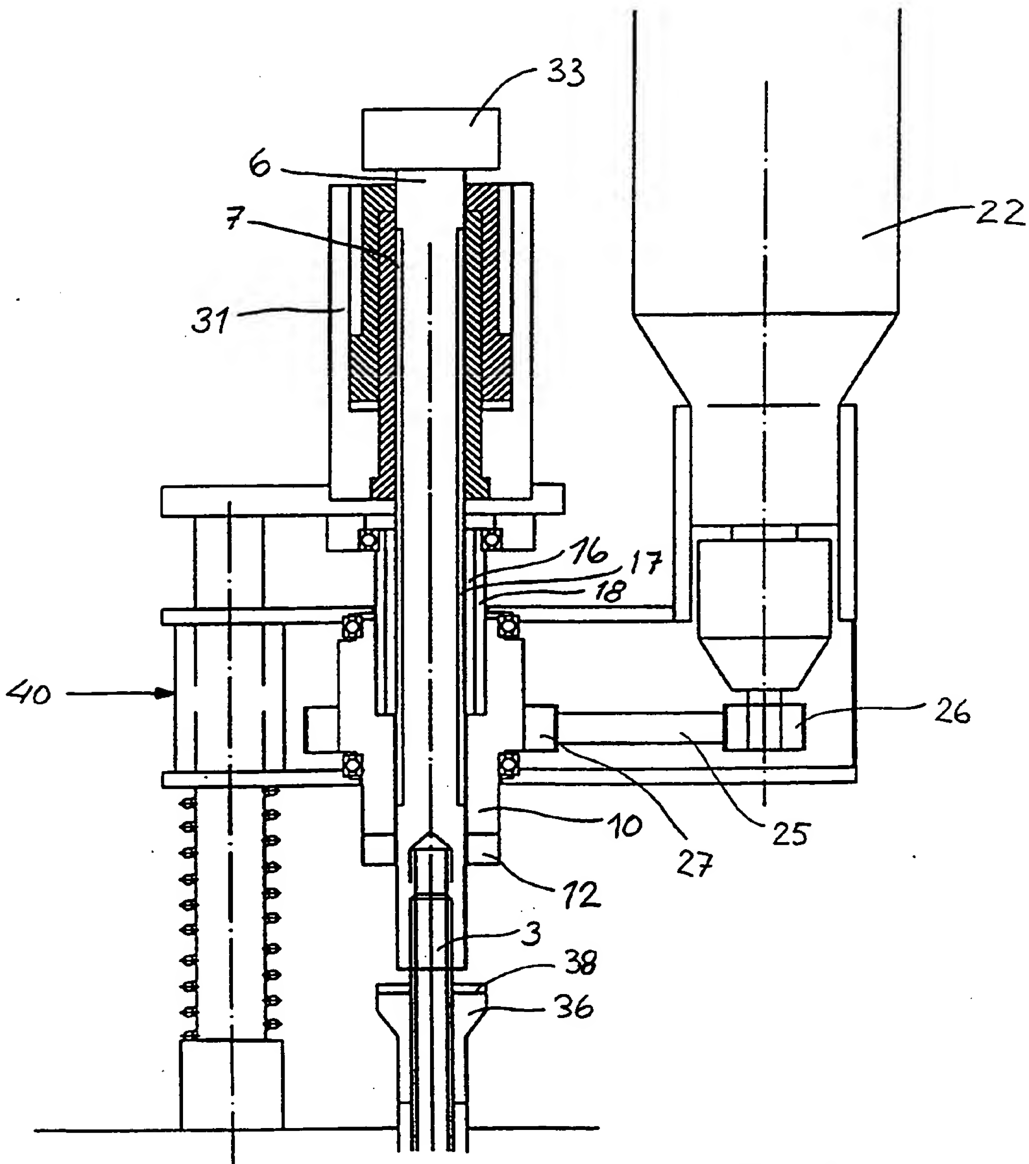

Fig. 2

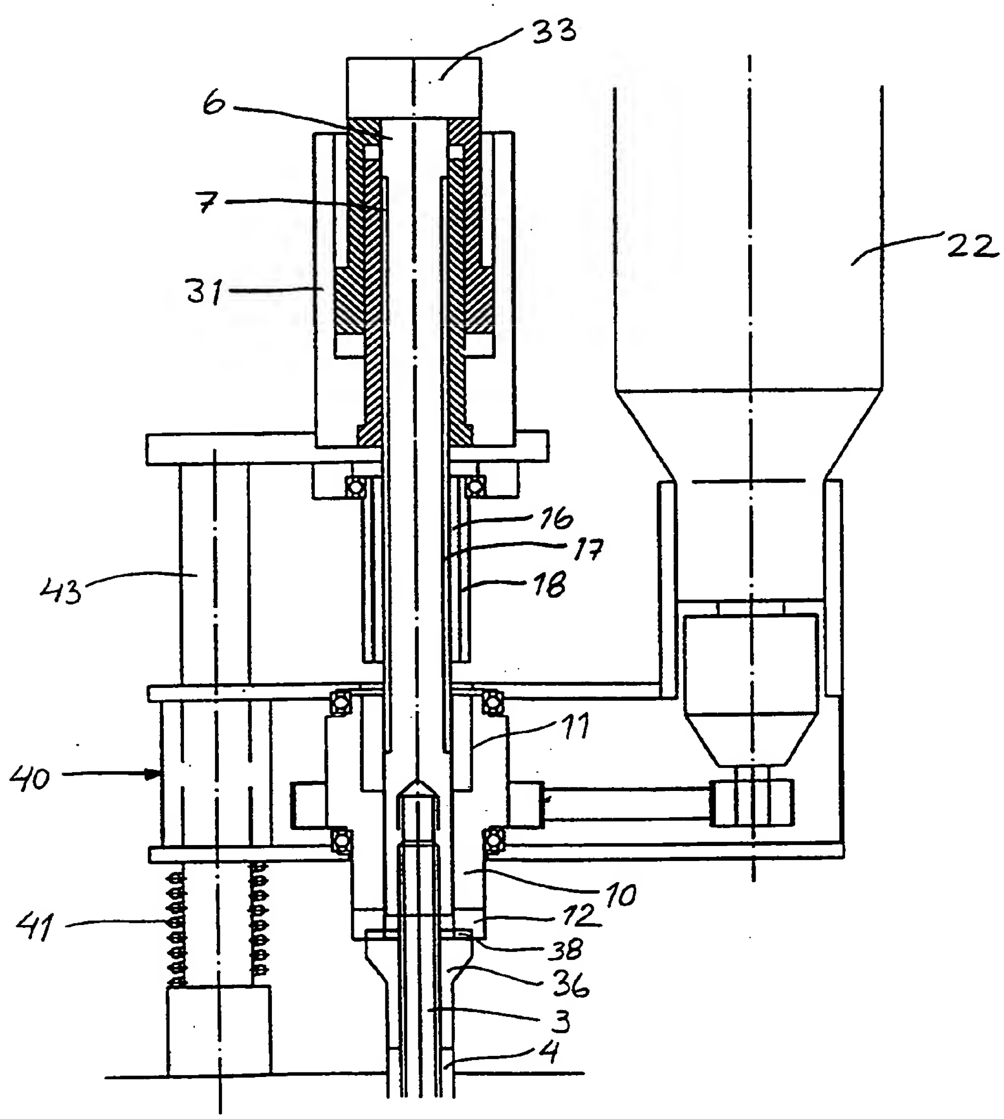

Fig. 3

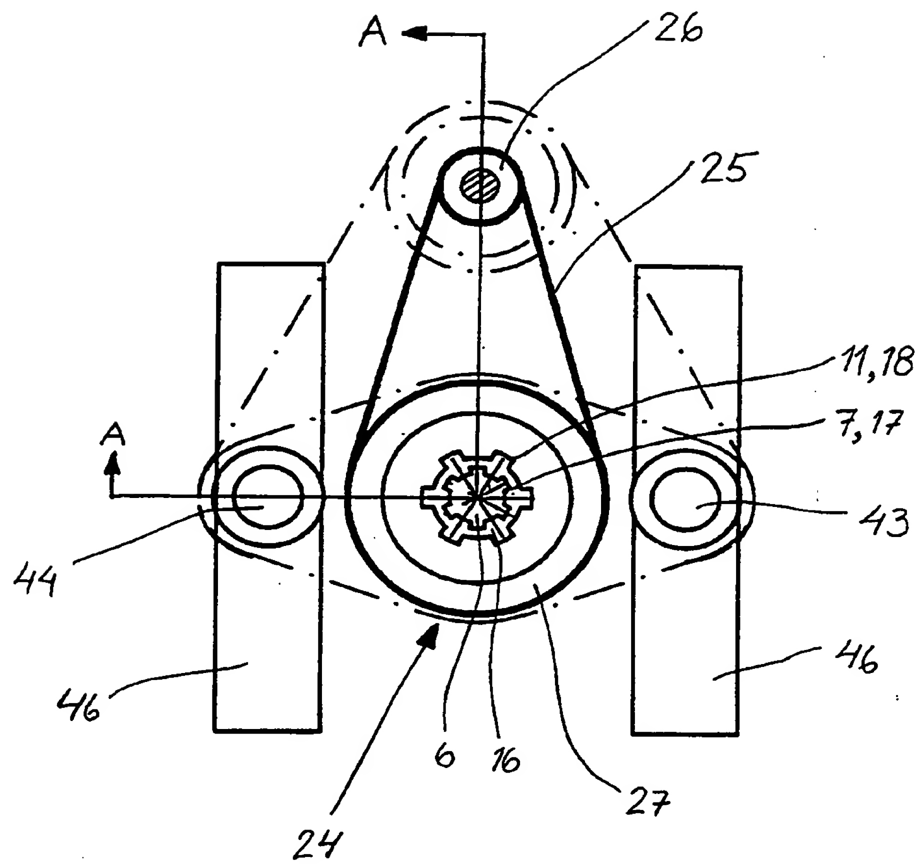

Fig. 4

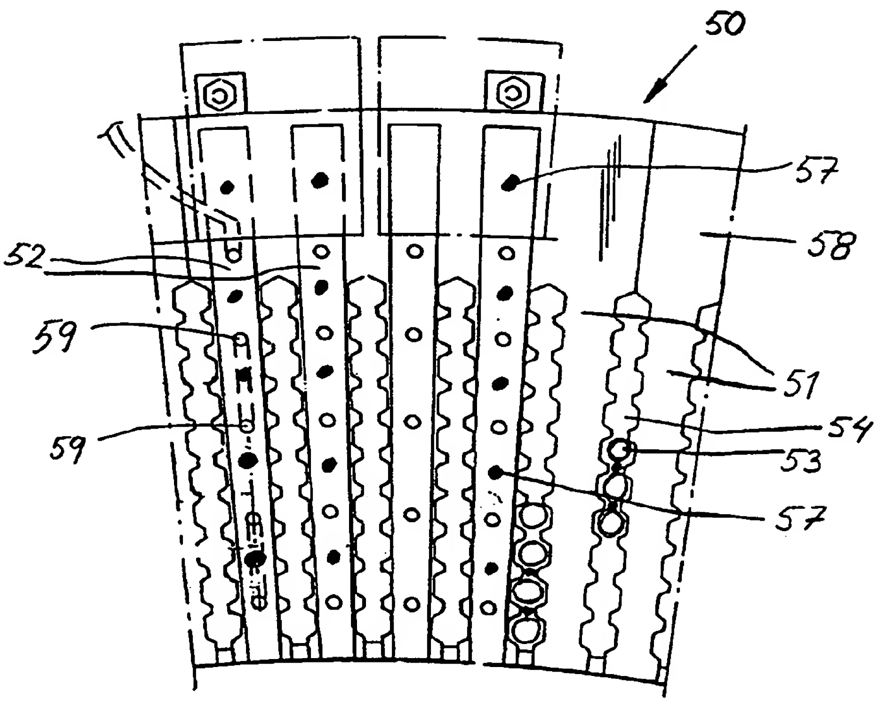

Fig. 5

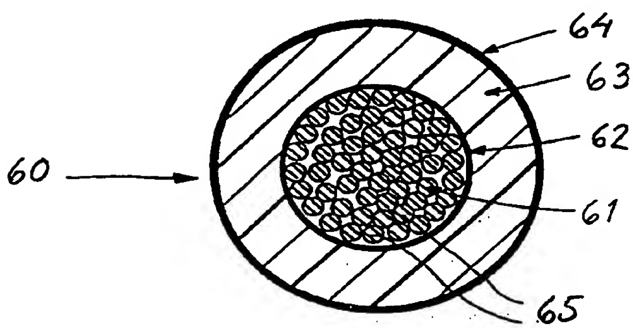

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01834

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 15/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0317248 A2 (WESTINGHOUSE ELECTRIC CORPORATION), 24 May 1989 (24.05.89), see the whole doc. --	1-29
Y	US 4785138 A (O.BREITENBACH ET AL), 15 November 1988 (15.11.88), see the whole doc. --	1-29
A	US 5036165 A (R. ELTON ET AL), 30 July 1991 (30.07.91), see the whole doc. -- --------	1-29

[ ] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 December 1998	29 -12- 1998

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE 98/01834

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0317248 A2	24/05/89	CN 1033911 A	12/07/89
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